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SPECIES ADAPTABILITY AND SEEDING SEASON FOR INCREASED FORAGE PRODUCTION IN NORTHEAST WASHINGTON



by

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RETURN TO: Revegetation

SPECIES ADAPTABILITY AND SEEDING SEASON FOR INCREASED
FORAGE PRODUCTION IN NORTHEAST WASHINGTON

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INTRODUCTION

The livestock industry is an important component of the regional economy in the six northeast Washington counties (fig. 1). Totaling almost 8 million acres or 18 percent of the state acreage, this region produced one-fifth of the beef cattle and one-eighth of the sheep reported in Washington in 1950 (7).^{1/} Approximately 100,000 acres of cropland in this area are used only for pasture and managed rather intensively. An additional 3 million acres, most of which have been classed as conifer-grass and foothill-grass, are suitable for grazing to some degree. Much of this acreage, although potentially productive, has been unwisely managed in the past and contributes little to the livestock industry. Native vegetation on a large part of these lands has been largely replaced by less desirable forbs, shrubs, and weedy annual grasses.

Industrial development and population increase within the region create an ever-increasing demand for livestock products. Washington at present produces less than half of the beef and even less of the mutton that is consumed in the state. In the interests of the livestock industry, low-producing lands should be returned to and managed for maximum sustained forage production. Concurrently, an objective of vital concern--soil and watershed protection--will also be met. In many instances, production of native ranges can be increased by improved management practices. Abandoned croplands and other areas that have lost most of their good forage species, however, can best be restored by artificially seeding to desirable forage species followed by wise management.

Extensive efforts have been made over the years to rehabilitate low-producing range and marginal croplands, but the results of workers elsewhere in the West have only limited application to this area because of soil and climatic differences. Although reported recommendations do provide guides that have universal application in the artificial revegetation field, e.g. clean, well-prepared seedbeds, drilling, etc., it is essential to determine techniques and species adaptability on local bases.

^{1/} Underlined numbers in parentheses refer to Literature Cited, page 25.

NORTHEAST WASHINGTON

- STUDY AREA**
- ★ adaptation and planting season
 - skidroad and trail
 - ◐ lodgepole pine burn

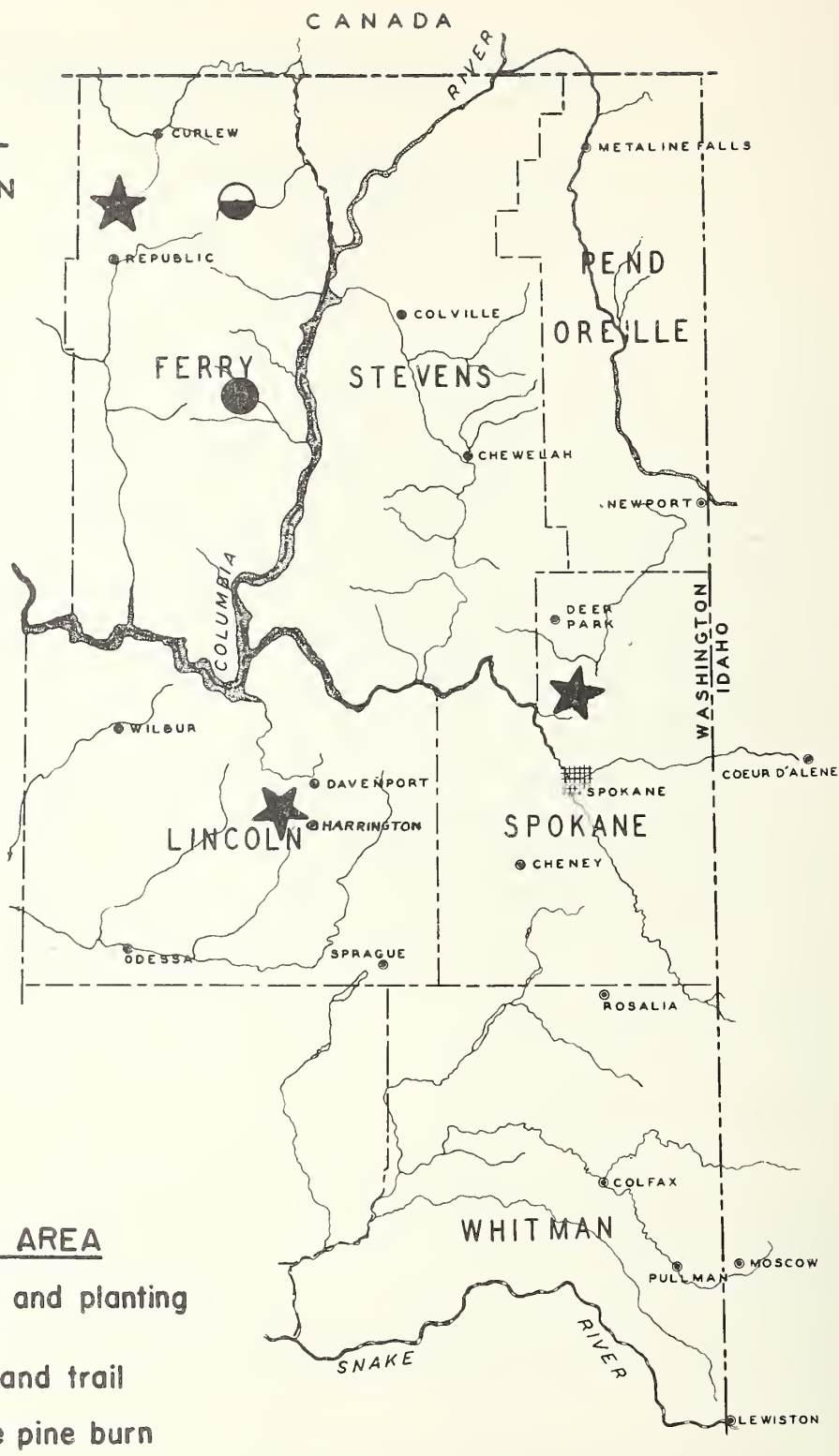


Figure 1.--Map of northeast Washington showing study area locations.

ADAPTATION TRIALS

Species adaptability and planting methods are commonly tested in small plots in artificial revegetation research. These results are then screened and the most promising species and methods are tested further in field-scale trials. The studies described herein were so designed originally but field trials were necessarily limited. Preliminary results of the small plot tests have been reported earlier (1), (2), (3), (4), and (9).

Test areas in Lincoln County characteristic of marginal croplands and in Ferry and Spokane Counties representing cleared woodlands that had been cropped and abandoned were selected for study (fig. 1). At these locations, seedings of a number of species, strains, and varieties of grasses and legumes were made in the spring and fall to determine adaptability and proper season of seeding. Each species was seeded with a Planet, Jr. seeder in plots consisting of three 18-foot rows spaced $1\frac{1}{2}$ feet apart. Seedbeds were prepared by plowing, hand raking, and packing. Competing weed species were removed twice during each growing season for 2 years following seeding.

Relative success of all seedings was determined periodically throughout each growing season using a rating scheme which considered plant distribution within the rows and plant survival and vigor. Greatest emphasis was placed on plant vigor in these trials when assigning the ratings. Number of plants was considered of lesser importance since seeding rate could not always be controlled and seed viability was not always known. Six rating classes--excellent, good, fair, poor, very poor, and failure--were used. When the results were evaluated, species were placed into four categories based on performance in seedings made in 2 or more years. These categories and the rating classes to which they refer are as follows:

<u>Performance category</u>	<u>Rating class</u>
Outstanding	Excellent
Successful	Good
Satisfactory	Fair
	(Poor
Unsatisfactory	(Very poor
	(Failure

Little significance is attached to results from 1 year's plantings, even though excellent, because of the relatively limited period of testing. Results from 1 year's plantings have been included primarily to summarize the revegetation research effort in this area.

Spokane County

The study area is near Chattaroy, Washington at an elevation of 2,200 feet on a ponderosa pine^{2/} site that had been cleared, farmed for several years, and abandoned. The soil has been classified as a Springdale gravelly loam (8) with a weak profile development, low humus content, excessive drainage, and a low water-holding capacity. Precipitation for this general locality averages about 20 inches annually with one-third of the total occurring during the months of April through September (table 1). The growing season averages about 3½ months (6). An estimated 20 percent of the soil surface was occupied by annual and perennial weedy vegetation; namely, cheatgrass, sheep sorrel, Heath forget-me-not, Douglas knotweed, low dogbane, flannel mullein, amaranth, and Klamath weed (fig. 2A). Five percent of the soil surface was covered by litter and the remaining 75 percent was bare.

Table 1.--Precipitation^{1/} at three northeast Washington stations by period and years in which seedlings were made at each study area

County, station, and year	P e r i o d		
	: April through	: Remaining	: Total
	: September	: 6 months	
	Inches	Inches	Inches
<u>Spokane County (Deer Park)</u>			
Norm	6.60	13.75	20.35
1950	2/4.95	2/18.04	-
1951	4.59	3/13.27	-
1952	4.50	9.94	14.44
1953	7.97	2/10.64	-
<u>Ferry County (Republic)</u>			
Norm	6.62	7.64	14.26
1948	2/15.10	3/3.36	-
1949	2.93	5.46	8.39
1950	3/3.83	4/5.61	-
1951	7.36	14.05	21.41
<u>Lincoln County (Harrington)</u>			
Norm	3.91	7.52	11.43
1950	4.69	13.21	17.90
1951	3.83	9.60	13.43
1952	3.67	5.13	8.80

- 1/ Weather Bureau climatological data, U. S. Dept. of Commerce
 2/ Record of 1 month lacking
 3/ Record of 2 months lacking
 4/ Record of 3 months lacking

2/ Common and botanical names of plants mentioned in this paper appear on pages 23 and 24.



Figure 2.--(A) Abandoned submarginal cropland in Spokane County, Washington having almost no grazing value. (B) Three-year-old spring-seeded crested wheatgrass and Intermediate wheatgrass stands in tests on an adjacent comparable area. Standard crested wheatgrass, first 3 rows from right; Fairway crested wheatgrass, next 3 rows; and intermediate wheatgrass extending left off the photo.

Twenty-nine species were seeded in the spring and fall of at least 2 years and several other species were tested in only one fall and spring seeding.

With one exception, spring seedings were superior to those made in the fall at this location. Stands resulting from the 1950 fall seeding were as successful as those made in the spring, but species performance in subsequent fall seedings was generally unsatisfactory.

Outstanding stands in the spring seedings (table 2) were produced by:

- Crested wheatgrass, 571
- Fairway crested wheatgrass (fig. 2B)
- Hard fescue
- Intermediate wheatgrass (fig. 2B)
- Orchardgrass, S-143
- Pubescent wheatgrass
- Standard crested wheatgrass (fig. 2B)
- Whitmar beardless wheatgrass

The stands produced by the following species were almost as successful:

- Manchar smooth brome
- Primar slender wheatgrass
- Sheep fescue
- Siberian wheatgrass
- Streambank wheatgrass
- Tall fescue
- Tall wheatgrass
- Timothy
- Western wheatgrass

Satisfactory stands were produced by green needlegrass, Russian wild-rye, and initially by Ladak alfalfa. The alfalfa was reduced to unsatisfactory status by the second growing season. Performance of the remaining species in the spring seedings was unsatisfactory. Of this latter group, a strain of common slender wheatgrass was the only failure experienced.

In the fall seedings, no species were outstanding but the following were successful:

- Crested wheatgrass, 571
- Intermediate wheatgrass
- Pubescent wheatgrass
- Timothy

Table 2.--Average success ratings^{1/} in 1953 of grass and legume species tested at three locations in northeast Washington by seeding season

Species	Spokane County		Ferry County			Lincoln County		
	Spring	Fall	Spring	Early fall	Late fall	Spring	Early fall	Late fall
Bluegrass, big, Sherman	VP(2)	VP(1)	^{2/} F(2)	-	F(2)	F(2)	-	VP(1)
" , " , " , P-89033/	F(1)	P(1)	-	-	-	F(1)	-	VP(1)
" , bulbous	P(2)	P(2)	F(2)	-	G(2)	X(1)	-	-
" , Canada, common	VP(2)	VP(2)	VP(2)	-	VP(2)	X(1)	-	-
" , " , P-410	P(2)	P(2)	-	-	-	F(1)	-	-
" , Canby	VP(2)	VP(2)	-	-	-	X(1)	-	-
" , Kentucky	F(1)	P(1)	VP(2)	-	X(2)	VP(1)	-	-
" , " , P-3128	F(1)	F(1)	-	-	-	-	-	-
Brome, mountain, Bromar	P(2)	P(2)	F(3)	VP(1)	P(3)	P(3)	X(1)	X(3)
" , " , common	VP(2)	VP(2)	VP(3)	X(1)	VP(3)	VP(1)	-	-
" , smooth, Lancaster	G(1)	VP(1)	-	-	-	E(1)	-	VP(1)
" , " , Lyon	E(1)	P(1)	-	-	-	E(1)	-	VP(1)
" , " , Manchar	G(2)	F(2)	E(3)	G(1)	G(3)	E(3)	X(1)	X(3)
Canarygrass, Reed, Superior	-	-	X(3)	X(1)	X(3)	VP(3)	X(1)	X(2)
Fescue, hard	E(3)	F(3)	G(3)	G(1)	G(3)	G(3)	X(1)	VP(3)
" , Idaho	P(3)	F(3)	-	-	-	F(3)	-	P(3)
" , " , P-6435	G(1)	F(1)	-	-	-	F(1)	-	F(1)
" , sheep	G(2)	F(3)	-	-	-	E(3)	X(1)	VP(2)
" , tall	G(2)	F(3)	VP(3)	X(1)	VP(3)	F(3)	X(1)	VP(2)
Foxtail, creeping	F(1)	VP(1)	-	-	-	-	-	-
" , meadow	-	-	-	-	P(1)	-	-	-
Needlegrass, green	F(2)	VP(2)	P(2)	-	VP(2)	F(1)	-	-
Oatgrass, tall, Tualatin	-	-	-	-	X(1)	-	-	-
Orchardgrass, common	-	-	G(3)	VP(1)	P(3)	F(3)	X(1)	X(3)
" , " , P-3135	E(1)	F(1)	-	-	-	E(1)	-	X(1)
" , " , S-143	E(3)	P(3)	G(3)	VP(1)	VP(2)	F(3)	X(1)	X(1)
Redtop	-	-	-	-	P(1)	-	-	-
Ricegrass, Indian	E(1)	P(2)	-	-	X(1)	G(2)	X(1)	VP(2)
Rye, mountain	-	-	-	-	-	F(1)	X(1)	-
Ryegrass, perennial	-	-	-	-	X(1)	-	-	-
Timothy, Asiatic	G(1)	G(1)	-	-	-	VP(1)	-	VP(1)
" , common	G(3)	G(3)	P(3)	VP(1)	VP(2)	F(3)	X(1)	X(3)
Wheatgrass, beardless, Whitmar	E(2)	F(2)	E(3)	G(1)	G(3)	G(2)	-	VP(1)
" , crested, Fairway	E(3)	P(3)	G(3)	G(1)	G(3)	E(3)	G(1)	G(2)
" , " , Standard	E(2)	F(2)	G(3)	F(1)	G(3)	E(3)	F(1)	G(2)
" , " , 571	E(3)	G(3)	G(1)	-	F(1)	E(2)	-	E(2)
" , intermediate	E(3)	G(3)	G(3)	G(1)	G(3)	E(3)	P(1)	P(3)
" , " , P-14	E(1)	G(1)	-	-	-	E(1)	-	P(1)
" , pubescent	E(3)	G(3)	E(3)	G(1)	E(3)	E(3)	X(1)	F(2)
" , Siberian	G(2)	X(1)	E(1)	-	F(1)	E(3)	F(1)	G(1)
" , " , P-27	G(1)	P(1)	-	-	-	-	-	-
" , slender, common	X(2)	X(2)	F(2)	X(1)	P(2)	F(2)	-	X(1)
" , " , " , P-1711	E(1)	G(1)	-	-	-	G(1)	-	X(1)
" , " , " , P-8039	E(1)	G(1)	-	-	-	-	-	-
" , " , Primar	G(3)	P(3)	G(3)	F(1)	G(3)	E(3)	VP(1)	VP(2)
" , streambank	G(2)	VP(3)	-	-	G(1)	E(2)	VP(1)	P(2)
" , " , P-2415	E(1)	P(1)	-	-	-	-	-	-
" , tall	G(3)	VP(3)	F(3)	F(1)	P(2)	E(3)	X(1)	P(3)
" , western	G(2)	P(2)	G(3)	F(1)	G(3)	E(3)	X(1)	VP(2)
Wildrye, blue	-	-	-	-	X(1)	-	-	-
" , Russian	F(2)	X(2)	G(3)	X(1)	VP(3)	G(1)	-	-
Alfalfa, creeping	P(2)	VP(2)	X(1)	VP(1)	VP(1)	G(3)	X(1)	VP(2)
" , Ladak	P(2)	VP(2)	VP(2)	VP(1)	X(2)	G(3)	VP(1)	X(2)
" , Siberian	-	-	-	-	-	E(1)	X(1)	-
Burnet, small	-	-	X(2)	X(1)	X(2)	P(3)	X(1)	X(3)
Clover, Alsike	-	-	-	-	-	-	-	-
" , strawberry	-	-	X(1)	-	-	-	-	-
" , white, Ladino	-	-	X(1)	-	X(1)	-	-	-
" , yellow sweet	-	-	-	-	-	-	-	-
Trefoil, big, Granger	F(1)	-	VP(2)	-	X(1)	F(1)	-	-
Milkvetch, sicklepod	P(2)	X(2)	-	-	-	X(1)	-	-

^{1/} E = excellent, G = good, F = fair, P = poor, VP = very poor, X = failure, - = not seeded.

^{2/} Numbers in parentheses indicate the number of years seedings were made.

^{3/} Accession numbers of seed obtained from Soil Conservation nursery at Pullman, Washington.

Satisfactory stands were produced by:

- Hard fescue
- Idaho fescue
- Manchar smooth brome
- Sheep fescue
- Standard crested wheatgrass
- Tall fescue
- Whitmar beardless wheatgrass.

The remaining species performed unsatisfactorily.

In spring and fall seedings of a single year of several species and strains, spring again proved to be the most suitable seeding season. Excellent stands were obtained with:

- Indian ricegrass
- Intermediate wheatgrass (P-14)
- Lyon smooth brome
- Orchardgrass (P-3135)
- Slender wheatgrass (P-1711, P-8039)
- Streambank wheatgrass (P-2415)

Somewhat less successful were the stands produced by:

- Asiatic timothy
- Idaho fescue (P-6435)
- Lancaster smooth brome
- Siberian wheatgrass (P-27).

Big trefoil, creeping foxtail, two strains of Kentucky bluegrass, and Sherman big bluegrass (P-8903) produced satisfactory stands but lacked the vigor and plant distribution of the preceding groups of species.

Plant establishment and vigor of the above species were generally less satisfactory (table 2) when fall-seeded. Although one season's results, such as these, are not considered adequate, they do confirm other results as to the superiority of spring seeding.

Based on the information obtained from the trials at this location, seven of the most successful species--Fairway crested wheatgrass, intermediate wheatgrass, orchardgrass (S-143), Primar slender wheatgrass, pubescent wheatgrass, tall wheatgrass, and Whitmar beardless wheatgrass--were selected for further testing on a larger basis. On a site similar to that used in the small plot trials and employing methods and equipment that would ordinarily be used by land owners, 1/5-acre seedings were made of each species in the spring (1953) using a single-disk grain drill.

The seedbed was plowed and floated before drilling. Each wheatgrass species was seeded at a rate of 8 pounds and orchardgrass at 6 pounds per acre to a depth of 1/2 to 3/4 inch.

Stand establishment and plant vigor for all species were outstanding in the first growing season (fig. 3). The seedlings were doubtless favored by abundant moisture during the earlier portion of the growing season (1.85 inches above normal for the period of April, May, and June). Although 6-inch row spacing may have resulted in some reduction of plant vigor, the loss was more than offset by the ability of the seeded stands to control weedy species.

Ferry County

Adaptation nursery

This area was considered typical of cleared woodlands which had been cropped for several years and abandoned. Located at an elevation of 2,450 feet, the area receives about 14 inches of precipitation annually (table 1), approximately one-half of which occurs during the months April through September. An average 3-month frost-free period occurs from June to September (6). The soil is a sandy loam underlain by gravel. There was no evidence that the area had ever been plowed but it had been subject to heavy past grazing use by horses. Cover vegetation occupied about 0.4 of the soil surface and was composed of 60 percent grass and 40 percent forb species. Needleandthread grass, green needlegrass, cheatgrass, Idaho fescue, Sandberg bluegrass, beardless wheatgrass, and bluebunch wheatgrass, in that order of abundance, made up the grass cover, and forbs consisted of woolly Indianwheat, aster, silky lupine, western yarrow, rose pussytoes, Wyeth erigonum, and flannel mullein.

Spring and late fall seedings of 26 grasses and legumes were made in 3 years and an early fall seeding in 1 year only at this location. In addition several other species were seeded in only one season of 1 year and will not be considered except for inclusion in table 2.

Spring seedings at this location usually resulted in more vigorous and evenly distributed plants than those made in the late fall. Stands resulting from the single early fall seeding were somewhat less successful than those made in late fall. The outstanding species at this location were Manchar smooth brome and Whitmar beardless wheatgrass when spring seeded, and pubescent wheatgrass in both spring and late fall seedings. Species performing successfully in spring and late fall seedings included:



Figure 3.--Spring-seeded intermediate wheatgrass (A) and
 Primar slender wheatgrass (B) stands on submarginal aban-
 doned cropland in Spokane County, Washington $3\frac{1}{2}$ months
 after seeding.

Spring

Fairway crested wheatgrass
Hard fescue
Intermediate wheatgrass
Orchardgrass, common
Orchardgrass, S-143
Primar slender wheatgrass
Russian wildrye
Standard crested wheatgrass
Western wheatgrass

Late fall

Bulbous bluegrass
Fairway crested wheatgrass
Hard fescue
Intermediate wheatgrass
Manchar smooth brome
Primar slender wheatgrass
Standard crested wheatgrass
Western wheatgrass
Whitmar beardless wheatgrass

A group of species that were considered satisfactory when seeded in the spring included:

Bromar mountain brome
Common slender wheatgrass
Sherman big bluegrass
Tall wheatgrass

Of this group, only Sherman big bluegrass produced satisfactory stands when seeded in the late fall. The following species produced successful stands initially in the spring seedings:

Common mountain brome
Common timothy
Creeping alfalfa
Ladak alfalfa
Reed canarygrass
Small burnet
Tall fescue.

However, after three to five growing seasons, the stands had either failed or were considered unsatisfactory. Pocket-gopher activity was largely responsible for the reduction of the alfalfa stands.

The most successful species from these tests--standard crested wheatgrass, intermediate wheatgrass, pubescent wheatgrass, and Manchar smooth brome--were selected for further field testing under conditions that normally confront the land owner. In cooperation with a local rancher, 6-acre seedings were made of each species in the spring of 1952 on abandoned cropland that had produced 7 to 8 bushels of rye per acre. Before plowing, the area supported a sparse cover of weed species such as tumbling Russian-thistle, Jim Hill mustard, cheatgrass, meadow salsify, woolly Indianwheat, and dandelion (fig. 4A). In addition to plowing, the area was well harrowed and packed before seeding. The species were seeded with an ordinary double disk grain drill at a rate of 8 pounds per acre. Seeding depth was about 1/2 inch. The area was packed again after seeding.



Figure 4.-- Abandoned cropland in Ferry County, Washington returned to production of livestock herbage. (A) Unseeded area supporting a sparse cover of low-value annual weeds. Camera case 8 inches high. (B) Comparable adjacent area seeded in April 1952 to crested wheatgrass and intermediate wheatgrass -- left and right, respectively, of Mr. Bremner. Photos taken June 1953.

Excellent crested wheatgrass and intermediate wheatgrass stands resulted from these seedings (fig. 4B). An equally successful stand of smooth brome was considerably reduced by winter killing, especially on wind-swept portions of the area. The pubescent wheatgrass stand was unexplainably spotty. Portions of this seeding ranged from excellent to failure and cannot be attributed to site variation or seeding technique since the entire area was treated similarly. All stands improved in the second and third growing seasons.

Lodgepole burn

Also in Ferry County, adaptability of 18 forage species was studied on burned-over lodgepole pine areas at an elevation of about 5,000 feet. The soil was of granitic origin interspersed with small to boulder-size fragments. The study sites were a portion of a 140,000-acre 1929 burn on which a dense, stagnated lodgepole pine stand had become established. Two blocks, each about 100 feet square, one facing southwest and the other northeast, were used in the study. The lodgepole pine reproduction was slashed and burned in the fall, and 18 forage species were individually broadcast in the ashes (fig. 5A).

After five growing seasons, species producing successful stands both in plant vigor and distribution on the southwest exposure (fig. 5B) included:

Redtop
Sheep fescue
Timothy.

Producing satisfactory stands initially but incapable of maintenance on this exposure were:

Alsike clover
Big bluegrass
Common orchardgrass
Tall catgrass.

Unsatisfactory performance at this location was obtained with:

Bluebunch wheatgrass
Green needlegrass
Intermediate wheatgrass
Ladak alfalfa
Manchar smooth brome
Pubescent wheatgrass
Russian wildrye
Small burnet
Standard crested wheatgrass
Tall fescue
Yellow sweetclover.



Figure 5.--(A) Condition of site after dense lodgepole pine reproduction (background) had been slashed and burned (foreground). (B) Fall-seeded in the ashes, timothy provides an adequate cover in the third growing season on the southwest exposure.

Under more favorable growing conditions on the northeast exposure, the following species continued to produce successful stands in the fifth growing season:

Pubescent wheatgrass
Redtop
Sheep fescue
Tall oatgrass.

Satisfactory performance was also obtained with:

Big bluegrass
Common orchardgrass
Intermediate wheatgrass
Manchar smooth brome
Tall fescue
Timothy
Whitmar beardless wheatgrass.

Unsatisfactory stands resulted with the remaining species tested:

Alsike clover
Green needlegrass
Ladak alfalfa
Russian wildrye
Small burnet
Standard crested wheatgrass
Yellow sweetclover.

Shrub encroachment at this location has increased, however, and may eventually result in a reduction of the more successful stands.

The apparent preference of game animals for south-facing slopes and the increased availability of forage on the area undoubtedly influenced species performance in this study. Alsike clover, yellow sweetclover, Manchar brome, and orchardgrass were heavily used, and redtop and tall fescue were used somewhat less, by deer and rabbits on the southwest-facing area soon after snow-melt. On the northeasterly exposure, however, only Alsike clover was used heavily and small burnet lightly, indicating that grazing by deer and rabbits was a lesser factor to species performance at this location than on the southwest-facing site.

Logged areas

Species suitability for revegetating skid roads, trails, and other areas disturbed by logging was also tested in the mixed ponderosa pine type in Ferry County. Replicated seedings at two southerly exposures, at 2,100 and at 4,100 feet elevation, were made in the fall upon

completion of logging activities. The soil was a shallow sandy loam of granitic origin, most of which had been removed during road construction and skidding. Consequently the resulting seedbed was compacted, rocky subsoil. Sixteen species were individually broadcast on plots 1/2-chain long and the width of the skid trail. After seeding, the plots were brush-dragged in an attempt to cover the seed. No effort was made to protect the seedlings from cattle grazing.

Species performance was quite similar at the two locations. Stand ratings were based primarily on plant distribution since all species were closely grazed. Despite heavy cattle use, successful stands were produced, in descending order, by:

- Redtop
- Chewings fescue
- Creeping red fescue
- Hard fescue
- Sheep fescue
- Timothy
- Orchardgrass

Manchar brome and Sherman big bluegrass produced satisfactory stands, but plant vigor was poor. Unsatisfactory performance was obtained with the following:

- Intermediate wheatgrass
- Pubescent wheatgrass
- Siberian wheatgrass
- Standard crested wheatgrass
- Tall oatgrass

The following three species failed:

- Beardless wheatgrass
- Blue wildrye
- Bromar mountain brome

It is of significance that several species became successfully established under heavy cattle use. With some degree of protection from grazing, in at least the initial growing season, performance probably would have been more satisfactory for a greater number of species.

Lincoln County

Adaptation trials at this location were concerned with 30 grass and legume species seeded in the spring and late fall of 3 years and early fall of 1 year on marginal cropland. The study area

is near Harrington, Washington, at an elevation of 2,200 feet and receives approximately 11.5 inches of precipitation annually, about one-third of which occurs during the months of April through September (table 1). An average frost-free period of nearly 4 months occurs during the months of June to late September (6). The soil has been classified as a Hesseltime loam (8)--a 6-inch brown loam surface layer underlain by 3 to 5 feet of rocky loam subsoil under which occurs basaltic bedrock. Excessive drainage and deficient organic matter discourage farming of this soil. The area had been abandoned after several years' cropping. Vegetation cover was composed of big sagebrush, cheatgrass, needleandthread grass, Sandberg bluegrass, and woolly Indianwheat (fig. 6A).

Spring seedings were superior to early and late fall seedings (table 2, fig. 6B). Crested wheatgrass was the only species that produced successful stands, and pubescent wheatgrass satisfactory stands, in the fall seedings. Outstanding species in the spring seedings included:

- Crested wheatgrass (3 strains)
- Intermediate wheatgrass
- Manchar smooth brome
- Primar slender wheatgrass
- Pubescent wheatgrass
- Sheep fescue
- Siberian wheatgrass
- Streambank wheatgrass
- Tall wheatgrass
- Western wheatgrass

Performance of the following species was considered somewhat less successful than the preceding group:

- Creeping alfalfa
- Hard fescue
- Indian ricegrass
- Ladak alfalfa
- Whitmar beardless wheatgrass.

Satisfactory stands in spring seedings have been maintained by the following species, although a reduction in plant vigor and numbers has occurred since the first growing season:

- Common orchardgrass
- Common slender wheatgrass
- Idaho fescue
- Orchardgrass, S-143
- Sherman big bluegrass
- Tall fescue
- Timothy.



Figure 6.--(A) General view of marginal cropland in Lincoln County, Washington with vegetation cover composed of cheatgrass, big sagebrush, Sandberg bluegrass, and needle-andthread grass, mainly. (B) Adjacent area on which small plot adaptation and seeding season trials were conducted. Two-year-old stands of spring-seeded fescue species in immediate foreground and taller wheatgrass species in center.

Successful initial stands of Bromar mountain brome, Reed canarygrass, and small burnet have gradually declined so that they were unsatisfactory by the third and fourth season. The remaining species that were tested either failed or were unsatisfactory in all respects.

DISCUSSION

Inasmuch as the adaptability trials were conducted solely on lands that were considered marginal or submarginal for cropping, the results may differ from those obtained by other workers on more productive lands in this general area. Maximum opportunity for establishment was also afforded by removal of competing vegetation during the first two growing seasons. Adaptability of several species and their ability to become established under competition was, however, confirmed on a limited scale in subsequent field plantings. The tests were made on areas characterized by droughty soils low in fertility with a low water-holding capacity. Reported results were obtained without fertilization. Precipitation during the trials ranged from above to below the norm so that species adaptability and seeding season were studied under varied moisture conditions.

The relative similarity in species adaptability and performance at the three sites, despite substantial differences in annual precipitation, can best be explained by soil textural differences. The pattern of precipitation is essentially the same at the three study areas, but the scantiness of precipitation in Lincoln County is accentuated by the longest growing season (table 3). At the Spokane County site, receiving the highest precipitation (20.35 inches), the upper 6- to 8-inch soil layer is very gravelly and is underlain by a porous substratum consisting mainly of gravel and boulders. Drainage throughout this soil type is excessive. The soil of the Ferry County site (annual precipitation 14.26 inches) is appreciably finer but also well-drained, approximately a 3-foot sandy loam underlain by gravel. At the Lincoln County site (precipitation 11.43 inches), 3 or more feet of well-drained, fine-textured loam is underlain by basaltic bedrock. Thus it happens that the study area receiving most precipitation has the soil with most rapid internal drainage and lowest water-holding capacity; the study area receiving least precipitation has the finest soil with highest water-holding capacity; and the study area with intermediate precipitation has a soil with intermediate soil-moisture characteristics. It therefore appears that differences in moisture-retaining qualities of these soils offset material differences in precipitation, and this accounts for the similarity in species adaptation and performance at the three study areas.

Table 3.--Average growing season and quarterly precipitation at three locations in northeast Washington

	:Spokane :County	: Ferry : County	: Lincoln : County
<u>Growing season</u>	102 days	96 days	119 days
<u>Precipitation</u>			
January through March	31 percent	25 percent	30 percent
April through June	20 "	29 "	23 "
July through September	12 "	17 "	11 "
October through November	37 "	29 "	36 "

Based on the findings of these tests, spring seedings are superior to late fall seedings. Although tested less adequately, early fall seeding was more unsatisfactory than late fall seeding. The success of late fall seedings in these tests probably would have been enhanced had they been delayed until late November or early December. However, because of inclement weather at that time, seedings usually must be made earlier. The results of the late fall seedings compare favorably with those of early fall seedings in central Utah reported by Frischknecht (5) and probably for similar reasons. The frost banding and heaving of seedlings noted in Utah were also evident in the early and late fall seedings of the tests reported here. This was particularly true at the Lincoln and Spokane County locations. Emerged seedlings from the fall seedings were subject to frost action before snow cover occurred in at least 2 years of the tests and again in the early spring following snowmelt. Many of the seedlings were completely heaved out of the soil, while the roots of others were so exposed that they died. Still others broke at the soil surface where the frost bands occurred. Species that were least susceptible to frost injury and heaving included crested (571), intermediate, and pubescent wheatgrasses in Spokane County and Siberian wheatgrass and three strains of crested wheatgrass in Lincoln County.

Seedling stands of adapted species from fall seedings in Ferry County were generally satisfactory and in most instances compared favorably with spring-seeded stands. Because of unfavorable growing conditions in the fall germination at this location, in all probability, did not occur until the following spring so that the seedlings were not subjected to alternate freezing and thawing.

SEEDING RECOMMENDATIONS

Under the conditions experienced during the period in which species adaptability and season of seeding were studied on marginal

or submarginal cropland at three locations in northeast Washington, certain recommendations for seeding can be made. For the general area encompassed in these studies, with precipitation ranging from $11\frac{1}{2}$ to about 20 inches annually, spring seeding results in the most successful stands. Predominantly coarse-textured and well-drained soils in this area can be worked soon after snowmelt (approximately late March). Unless seedings can be made late enough in the fall so that germination does not occur until spring, fall seedings should not be attempted.

Suitable species for seeding in this area are: hard fescue, Manchar brome and crested (Fairway, standard, and 571), intermediate, Primar slender, pubescent, Siberian, western, and Whitmar beardless wheatgrasses. Tall wheatgrass, given only a satisfactory rating in the Ferry County trials, has been successful in subsequent field tests in that area and can be included in the preceding group. Indian ricegrass, sheep fescue, and streambank wheatgrass were not tested at the Ferry County location which receives about 14 inches of annual precipitation. However, successful performance of these species when spring-seeded at the Lincoln and Spokane County areas receiving $11\frac{1}{2}$ and 20 inches of annual precipitation, respectively, suggest that they would also be suitable for the entire area. Spring seedings of timothy and tall fescue can be expected to be successful in areas with 20 or more inches of annual precipitation. Orchardgrass (S-143) can be successfully spring-seeded in those portions of northeast Washington where precipitation averages 14 or more inches annually. Successful stands of creeping and Ladak alfalfa may be obtained in areas with fine-textured soils receiving as little as $11\frac{1}{2}$ inches of precipitation.

To restore cover vegetation on skid roads and trails in the mixed ponderosa pine type, seedings should be made soon after logging operations have been completed to take advantage of the loose, disturbed soil which provides a satisfactory bed for broadcast seed. Although some seed is covered by soil sloughing, a brush drag or a section of a spike-tooth harrow is more reliable and efficient. Redtop, Chewings, creeping red, hard, and sheep fescues, timothy, and orchardgrass are suitable species for seeding logged-over areas.

Satisfactory cover vegetation for burned-over densely stocked lodgepole pine areas can be obtained by broadcast seeding in the ashes soon after the burn. Adapted species for northerly and southerly exposures at an elevation of 5,000 feet include redtop, sheep fescue, and timothy. In addition, big bluegrass, common orchardgrass, intermediate wheatgrass, Manchar brome, pubescent wheatgrass, tall oatgrass, tall fescue, and Whitmar beardless wheatgrass are also suitable on northerly exposures.

Though seeding methods were not studied in these trials, experience here and elsewhere has shown that drilling in a clean, firm seedbed is the most satisfactory method of seeding. In some situations,

however, because of slope and stoniness, less desirable methods of seedbed preparation and seeding are more practicable. For most species, seeding depth should not exceed $3/4$ inch, $1/2$ inch being preferable. In this area, packing after drilling has been found to enhance seeding results.

Six-inch row spacing, in range and field seedings to be used for grazing, provides a good ground cover. Although the seeded plants may be less vigorous than plants in wider spacings, weeds are usually more effectively controlled. (For seed production, however, wide spacing from 30 to 36 inches, produces the greatest yields.) Clipping of weedy seedings in the initial growing season is commonly done to prevent seed formation and to reduce competition. Generally clipping in the first season is adequate but where wide spacings are used, control of weeds may be necessary for a longer period until the seeded species are sufficiently established to dominate the area.

Such items as seed size, purity, and germinability, planting method, and condition of seedbed must be considered in determining seeding rate. Generally drilling in a well-prepared seedbed and using good seed, a 7 to 8 pounds per acre rate is adequate for large-seeded species such as tall wheatgrass and smooth brome; and with big bluegrass, sheep fescue, and other species with small seed 4 to 5 pounds per acre is recommended. The seeding rate should be increased by one-third to one-half on poor seedbeds or when seed is broadcast. Further adjustments in seeding rates may be necessary depending upon seed viability and foreign material in the seed.

As a general rule, seedings should be completely protected during the establishment period to permit the new plants maximum opportunity of developing a good root system. Usually, conservative use can be made of the stands late in the second growing season. On droughty soils where plant establishment is slow and with species such as big bluegrass that develop root systems slowly, grazing should be deferred until the third season. Frequently the cost of deferment can be more than offset by harvesting a seed crop in the second season. Maintenance of seeded stands is dependent upon management practices. Heavy prolonged grazing reduces plant vigor and permits the invasion of less desirable species. Spring grazing should be of the type that will permit the plants to make ample regrowth after the animals are removed. Grazing in the summer and/or fall should allow about half the plant's volume to remain for soil protection and maintenance of plant vigor.

COMMON AND BOTANICAL NAMES OF SPECIES DISCUSSED

Grasses

Asiatic timothy	<i>Phleum phleoides</i>
Beardless wheatgrass	<i>Agropyron inerme</i>
Big bluegrass	<i>Poa ampla</i>
Bluebunch wheatgrass	<i>Agropyron spicatum</i>
Blue wildrye	<i>Elymus glaucus</i>
Bulbous bluegrass	<i>Poa bulbosa</i>
Canada bluegrass	<i>Poa compressa</i>
Canby bluegrass	<i>Poa canbyi</i>
Cheatgrass	<i>Bromus tectorum</i>
Chewings fescue	<i>Festuca rubra</i> var. <i>commutata</i>
Creeping foxtail	<i>Alopecurus arundinacea</i>
Creeping red fescue	<i>Festuca rubra</i>
Crested wheatgrass	<i>Agropyron cristatum</i>
Green needlegrass	<i>Stipa viridula</i>
Hard fescue	<i>Festuca ovina</i> var. <i>duriuscula</i>
Idaho fescue	<i>Festuca idahoensis</i>
Indian ricegrass	<i>Oryzopsis hymenoides</i>
Intermediate wheatgrass	<i>Agropyron intermedium</i>
Kentucky bluegrass	<i>Poa pratensis</i>
Meadow foxtail	<i>Alopecurus pratensis</i>
Mountain brome	<i>Bromus marginatus</i>
Mountain rye	<i>Secale montanum</i>
Needleandthread grass	<i>Stipa comata</i>
Orchardgrass	<i>Dactylis glomerata</i>
Perennial ryegrass	<i>Lolium perenne</i>
Pubescent wheatgrass	<i>Agropyron trichophorum</i>
Redtop	<i>Agrostis alba</i>
Reed canarygrass	<i>Phalaris arundinacea</i>
Russian wildrye	<i>Elymus junceus</i>
Sandberg bluegrass	<i>Poa secunda</i>
Sheep fescue	<i>Festuca ovina</i>
Siberian wheatgrass	<i>Agropyron sibiricum</i>
Slender wheatgrass	<i>Agropyron trachycaulum</i>
Smooth brome	<i>Bromus inermis</i>
Streambank wheatgrass	<i>Agropyron riparium</i>
Tall fescue	<i>Festuca elatior</i> var. <i>arundinacea</i>
Tall oatgrass	<i>Arrhenatherum elatius</i> var. <i>Tualatin</i>
Tall wheatgrass	<i>Agropyron elongatum</i>
Timothy	<i>Phleum pratense</i>
Western wheatgrass	<i>Agropyron smithii</i>

Forbs

Alfalfa	<i>Medicago sativa</i> var. <i>media</i>
Alsike clover	<i>Trifolium hybridum</i>
Amaranth	<i>Amaranthus</i> sp.
Aster	<i>Aster</i> sp.
Big trefoil	<i>Lotus uliginosus</i>
Dandelion	<i>Taraxacum officinale</i>
Douglas knotweed	<i>Polygonum douglasii</i>
Flannel mullein	<i>Verbascum thapsus</i>
Heath forget-me-not	<i>Myosotis stricta</i>
Jim Hill mustard	<i>Sisymbrium altissimum</i>
Klamath weed	<i>Hypericum perforatum</i>
Low dogbane	<i>Apocynum pumilum</i>
Meadow salsify	<i>Tragopogon pratensis</i>
Rose pussytoes	<i>Antennaria rosea</i>
Sheep sorrel	<i>Rumex acetosella</i>
Siberian alfalfa	<i>Medicago falcata</i>
Sicklepod milkvetch	<i>Astragalus falcatus</i>
Silky lupine	<i>Lupinus sericeus</i>
Small burnet	<i>Sanguisorba minor</i>
Strawberry clover	<i>Trifolium fragiferum</i>
Tumbling Russian-thistle	<i>Salsola kali</i> var. <i>tenuifolia</i>
Western yarrow	<i>Achillea lanulosa</i>
White clover, Ladino	<i>Trifolium repens</i>
Woolly Indianwheat	<i>Plantago purshii</i>
Wyeth eriogonum	<i>Eriogonum heracleoides</i>
Yellow sweetclover	<i>Melilotus officinalis</i>

Shrubs & Trees

Big sagebrush	<i>Artemisia tridentata</i>
Lodgepole pine	<i>Pinus contorta</i> var. <i>latifolia</i>
Ponderosa pine	<i>Pinus ponderosa</i>

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